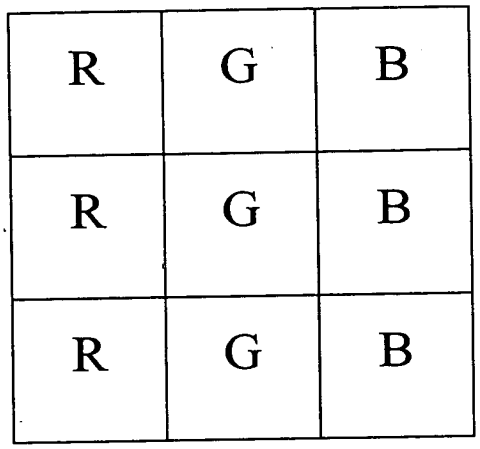

Fig. 1a

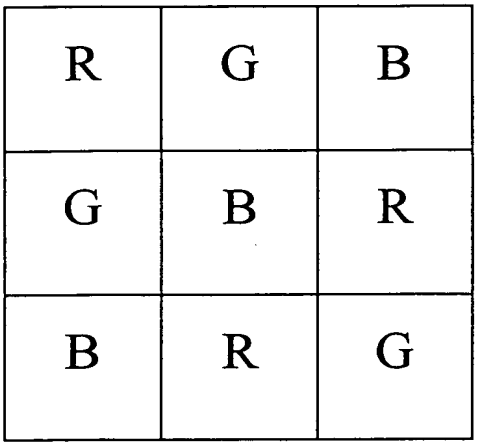

Fig. 1b

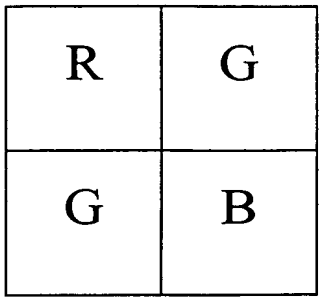

Fig. 1c

Step 1: Calculate the low-pass filtered luminance of the image
(from the data of the pixel and its neighbor pixels)

Step 2: Calculate the chrominance of each pixel
(only the chrominance channel which corresponds with the color filter of the pixel)

Step 3: Interpolate chrominances in each pixel with a 'vote' operator
(use the chrominance data of a small set of pixels around the pixel)

Step 4: Calculate the high-resolution luminance data of each pixel
(from the chrominance and the sensor data of the pixel)

Step 5: Calculate the full color (RGB) image
(from the luminance and the chrominance data)

Fig:2

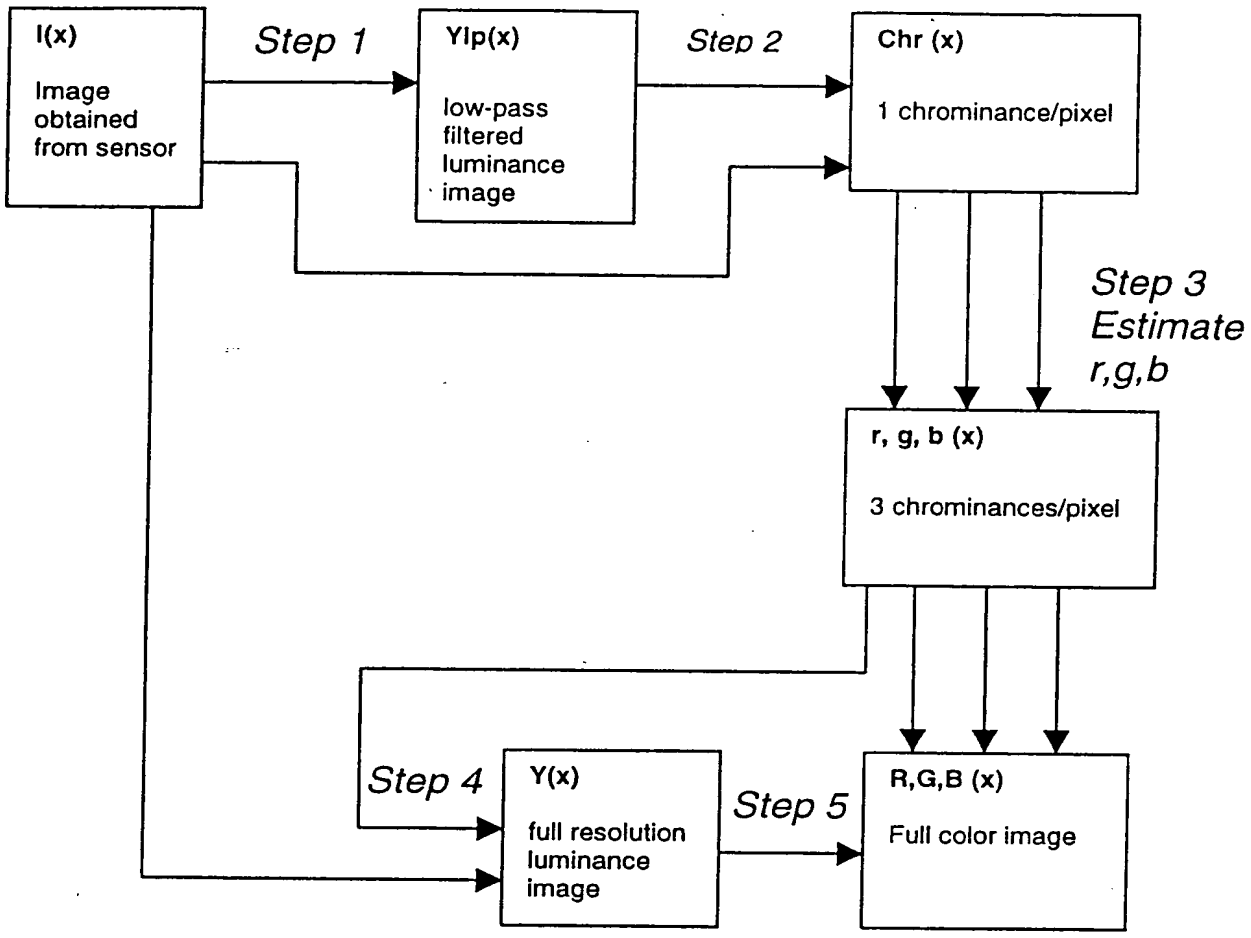
I(x)
Image obtained from sensor
Step 1
Ylp(x)
low-pass filtered luminance image
Step 2
Chr (x)
1 chrominance/pixel
Step 3
Estimate
r,g,b
r, g, b (x)
3 chrominances/pixel
Step 4
Y(x)
full resolution luminance image
Step 5
R,G,B (x)
Full color image

Fig. 3

Consider a window of 11 pixels around the pixel the colour of which is to be determined.

Step 1: For the 9 middle pixels of this window

Calculate $Ylp(x) = [I(x-1) + I(x) + I(x+1)]/3$

$Ylp(x)$ is the low-pass filtered luminance of the pixel at position x.

Step 2 : Calculate for the 9 middle pixels of this window:

For additive color processing

$Chr(x) = I(x) - Ylp(x)$

For multiplicative color processing

$Chr(x) = I(x)/Ylp(x)$

$Chr(x)$ is the estimated chrominance of the pixel at position x which corresponds with the color of the pixel at position x

3 red, 3 green and 3 blue chrominances are calculated r1, r2, r3, b1, b2, b3, g1, g2, g3

Step 3 : Estimate from the 3 chrominances from a color channel the chrominances r,g,b of the pixel:

$r = vote\{r1, r2, r3\}$

$g = vote\{g1, g2, g3\}$

$b = vote\{b1, b2, b3\}$

Step 4 : Calculate full-resolution luminance Y

For additive color processing

$Y = I - \{r \text{ or } g \text{ or } b\}$

For multiplicative color processing

$Y = I/\{r \text{ or } g \text{ or } b\}$

Y is the luminance of the pixel that is interpolated

I is the pixel intensity of this pixel, measured by the image sensor

{r or g or b} : the chrominance which corresponds with the color filter of the pixel is chosen

Step5 : For additive color processing

$R = Y + r$

$G = Y + g$

$B = Y + b$

For multiplicative processing

$R = Y^*r$

$G = Y^*g$

$B = Y^*b$

Fig. 4

The green pixel G5 needs to be interpolated. The pixel array looks as follows:

```
B0   R1   G2   B3   R4   G5   B6   R7   G8   B9   R10
```

Step 1 : Calculate Ylp

```
Ylp1 = {B0 + R1 + G2}/3      Ylp2 = {R1 + G2 + B3}/3      Ylp3={G2 + B3 + R4}/3
Ylp4 = {B3 + R4 + G5}/3      Ylp5 = {R4 + G5 + B6}/3      Ylp6={G5 + B6 + R7}/3
Ylp7 = {B6 + R7 + G8}/3      Ylp8 = {R7 + G8 + B9}/3      Ylp9={G8 + B9 + R10}/3
```

Step 2 : calculate chrominance of each pixel

```
r1 = R1/Ylp1      g2 = G2/ylp2      b3 = B3 / Ylp3
r4 = R4/Ylp4      g5 = G5/ylp5      b6 = B6 / Ylp6
r7 = R7/Ylp7      g7 = G8/ylp8      b9 = B9 / Ylp9
```

Step 3 : chrominance interpolation

```
r=vote{r1,r2,r3}
g=vote{g1,g2,g3}
b=vote{b1,b2,b3}
```

Step 4 : calculate high-resolution luminance

```
Y=G5/g
```

Step 5 : calculate RGB data

Fig. 5

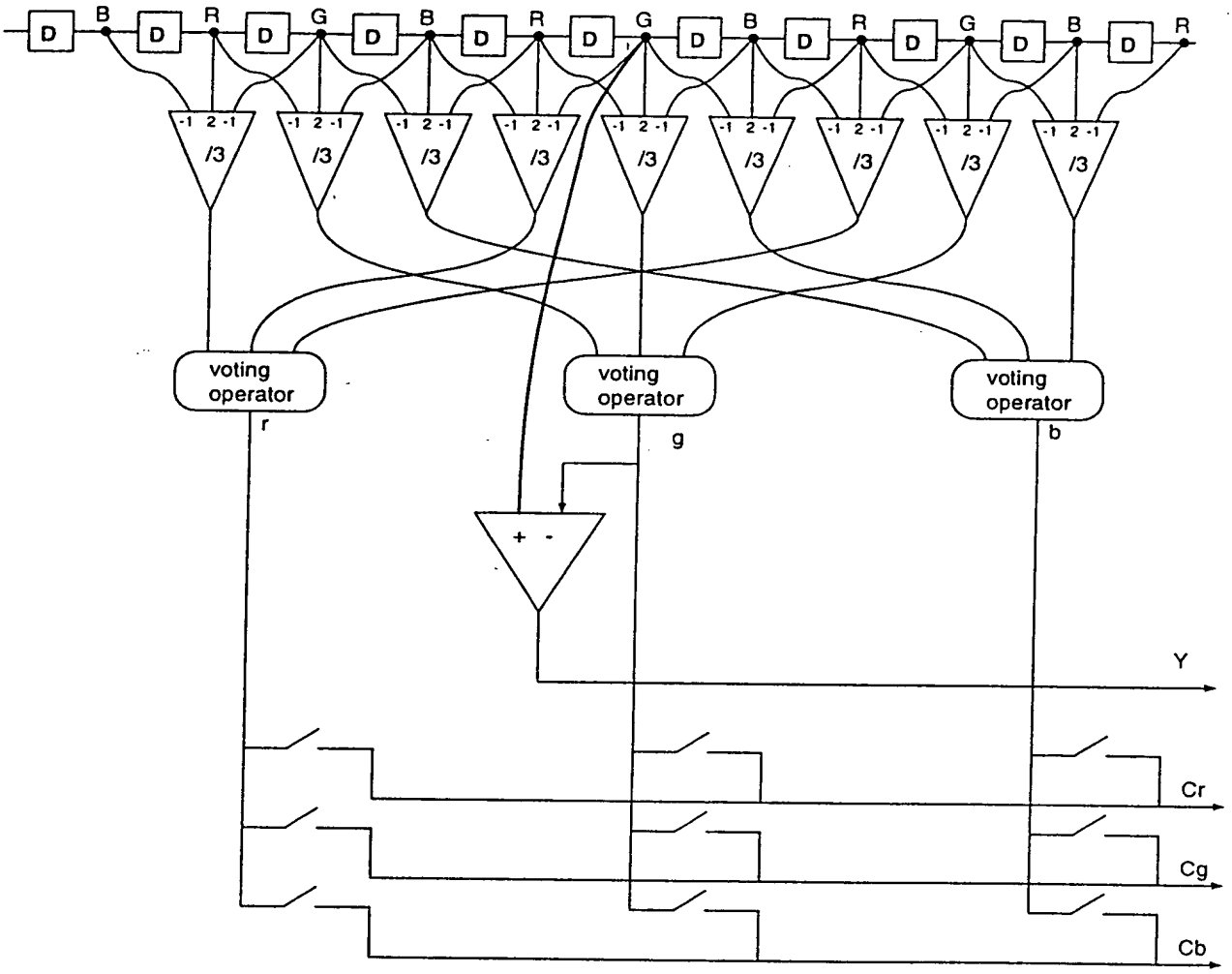

Fig. 6

Electrical specifications		
signal range	2-4 V	
Noise	< 1.3 mV	RMS variation on output
S/N ratio	64 dB	1670:1
Pixel frequency	typ. 8 MHz	
Output data delay	80 ns	after rising clock edge, 1 V swing, error < 10 mV
Rise time	84 ns	1 V swing, rising signal
Signal slew rate	12 V/μs	
Dissipation	100 mW	at 8 MHz including 3 output amplifiers
Dimensions		
PR 16 cell	1.7 x 1 mm^2	without pads
PR 16 IO	2.5 x 1.7 mm^2	includes bond pads
Package	28 pins DIL	
Process	0.7 μm	analog/digital CMOS

Fig. 7

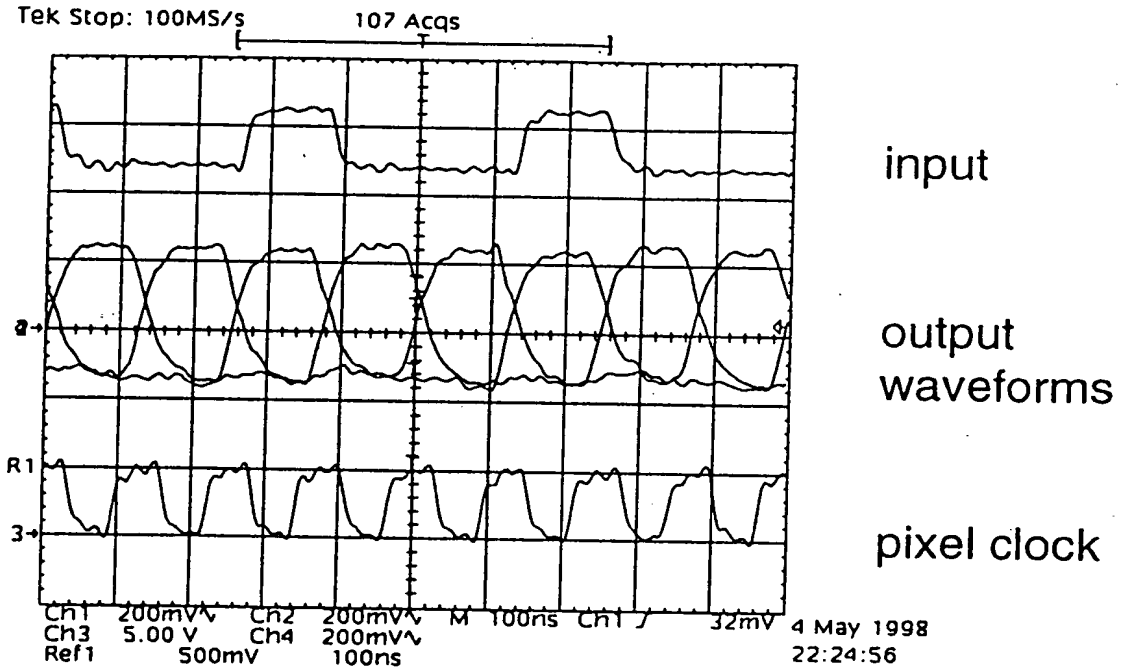
Tek Stop: 100MS/s
107 Acqs
input
output waveforms
pixel clock
R1
3
Ch1 200mV
Ch2 200mV
M 100ns Ch1 32mV
Ch3 5.00 V
Ch4 200mV
Ref1 500mV 100ns
4 May 1998
22:24:56

Fig. 8

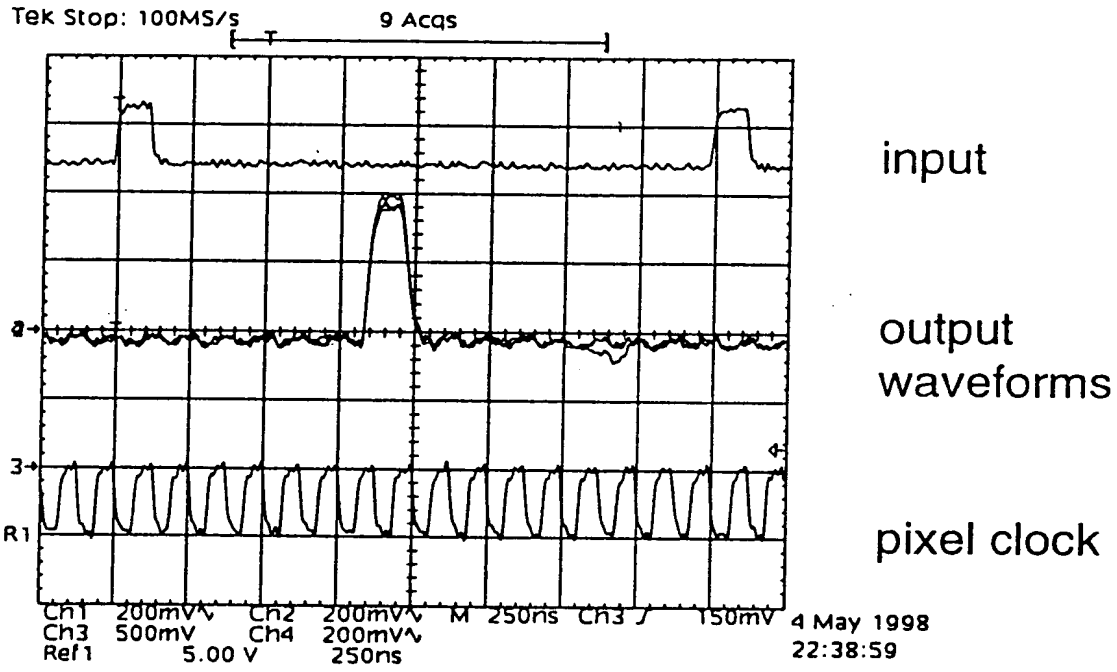
Tek Stop: 100MS/s
9 Acqs
input
output
waveforms
pixel clock
Ch1 200mV
Ch2 200mV
M 250ns Ch3
150mV
Ch3 500mV
Ch4 200mV
Ref1 5.00 V
250ns
4 May 1998
22:38:59

Fig. 9

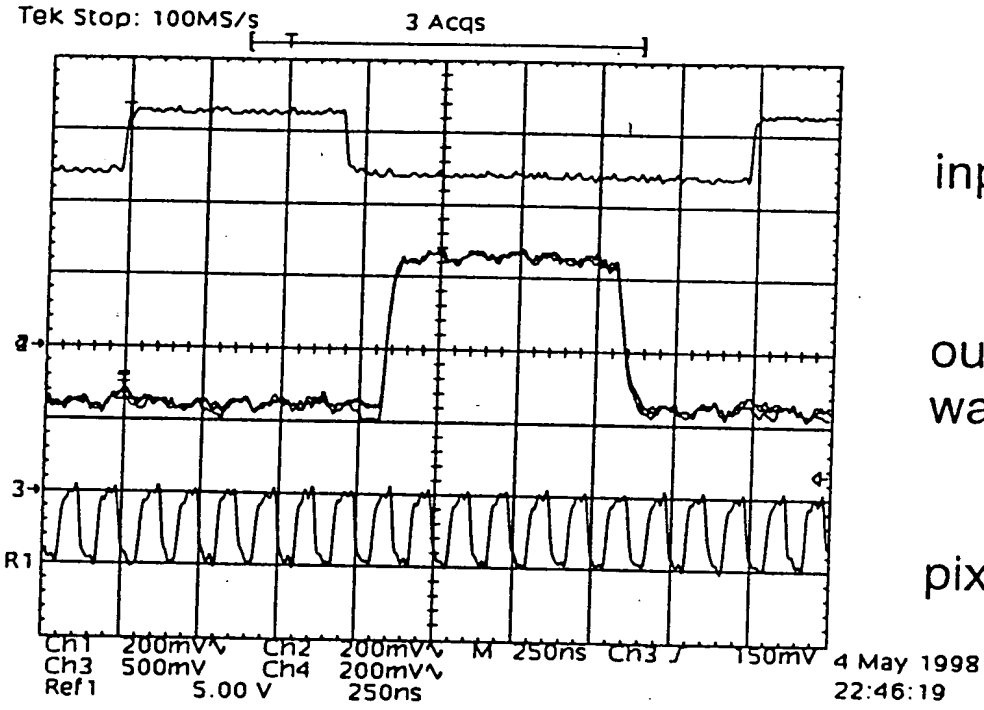

Fig. 10

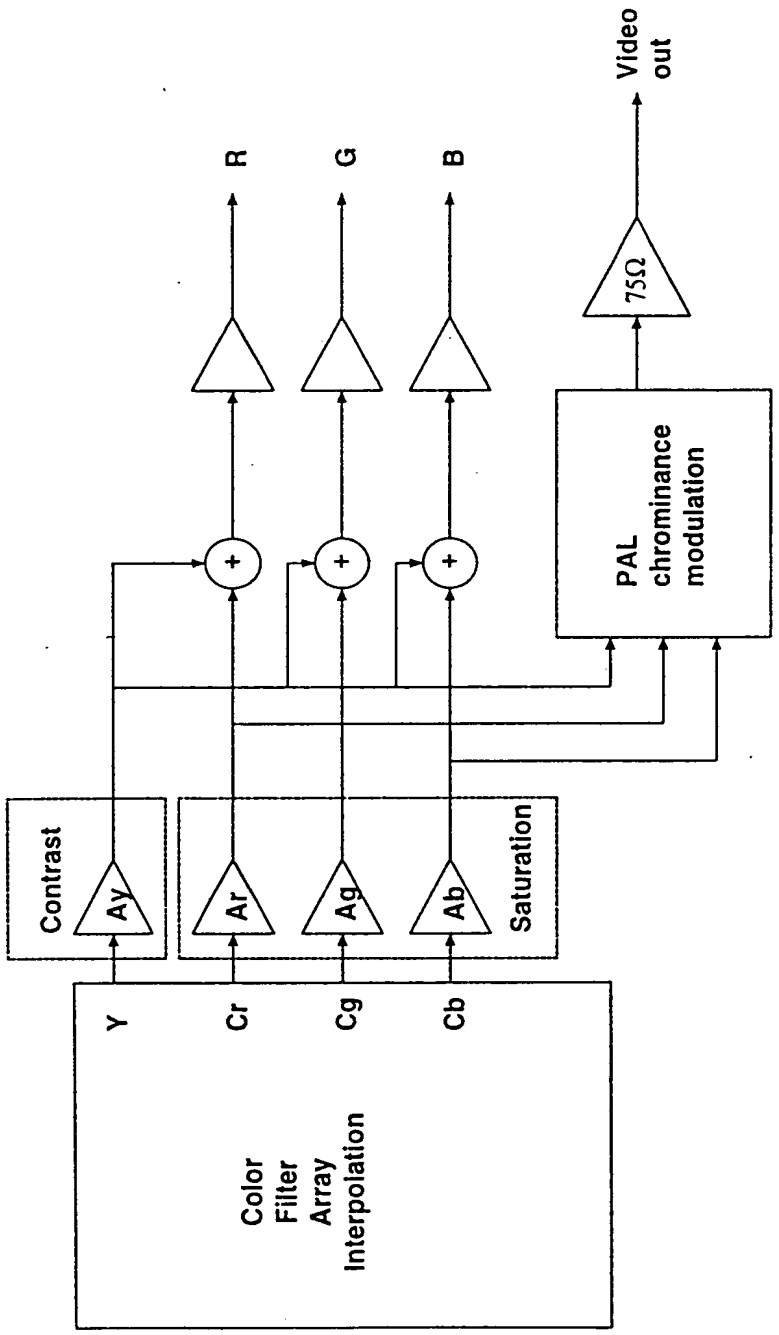
Video out
R
G
B
75Ω
PAL chrominance modulation
+
+
+
Contrast
Ay
Ar
Ag
Ab
Saturation
Y
Cr
Cg
Cb
Color Filter Array Interpolation

Fig. 11

B1	R2	G3
R4	G5	B6
G7	B8	R9

Method for interpolating pixel at position 5:

1) Calculate a low-pass filtered image:
   Y2 = (B1 + R2 + G3)/3
   Y5 = (R4 + G5 + B6)/3
   Y8 = (G7 + B8 + R9)/3

2) Calculate chrominance of each pixel
   b1 = B1 - Y2 r2 = R2 - Y2 g3 = G3 - Y2
   r4 = R4 - Y5 g5 = G5 - Y5 b6 = B6 - Y5
   g7 = G7 - Y8 b8 = B8 - Y8 r9 = R9 - Y8

3) Interpolation
   r5* = median {r2, r4, r9}
   g5* = median {g3, g5, g7}
   b5* = median {b1, b6, b8}

4) Luminance of pixel 5
   Y5 = I5 - g5

5) RGB data of pixel 5
   R5* = Y5 + r5
   G5* = Y5 + g5
   B5* = Y5 + b5

Fig. 12